

WE CLAIM:

- 1 1. A method for substantially uniformly coating an interior surface of a
2 tubular structure, said method comprising:
3 inducing a magnetic field having a given magnitude within the tubular
4 structure;
5 applying a bias at a given voltage to the tubular structure; and
6 exposing the interior surface to a gaseous precursor material under conditions
7 effective to convert a quantity of the gaseous precursor material to
8 ionized gaseous precursor material, the given magnitude and voltage
9 being effective to deposit the ionized gaseous precursor material onto
10 the interior surface and to convert the ionized gaseous precursor
11 material to a substantially uniform protective coating on the interior
12 surface.
- 1 2. The method of claim 1, further comprising positioning a tubular
2 structure relative to a magnetic field source such that the magnetic field is generated
3 from within the tubular structure.
- 1 3. The method of claim 2, wherein said positioning includes providing a
2 tubular structure having a high aspect ratio.
4. The method of claim 2, wherein said positioning includes providing a
tubular structure comprising ferromagnetic material.

1 5. The method of claim 2, wherein said positioning includes positioning a
2 magnetic assembly, as the magnetic field source, within the tubular structure and
3 generating the magnetic field therefrom.

1 6. The method of claim 5, wherein said positioning comprises positioning
2 a plurality of magnets within and along the length of the tubular structure, and said
3 inducing comprises, generating a plurality of magnetic fields having the same
4 direction.

1 7. The method of claim 1, further comprising exposing the interior
2 surface of the tubular structure to inert gas under conditions effective to clean the
3 interior surface prior to exposing the interior surface to gaseous precursor material
4 and after inducing a magnetic field.

1 8. The method of claim 7, wherein said gas is argon.

1 9. The method of claim 1, wherein said exposing comprises selecting
2 gaseous precursor material from the group consisting of SiH_4 ; CH_4 ; C_2H_2 ; N_2 ;
3 $\text{Cr}(\text{CO})_6$ and combinations thereof.

1 10. The method of claim 1, further comprising rotating at least one of the
2 tubular structure and the magnetic field source during said exposing.

1 11. The method of claim 1, further comprising passing coolant during the
2 exposing in the vicinity of said magnetic field source, thereby cooling said magnetic
3 field source.

1 12. The method of claim 11, wherein said passing includes passing water
2 in the vicinity of said magnetic field source.

1 13. The method of claim 1, wherein said applying a bias includes applying
2 a positive bias to said magnetic field source.

1 14. The method of claim 1, wherein said exposing is performed under
2 conditions including a vacuum pressure of from about 0.5 to about 100 millitorr, and a
3 negative voltage having a pulse frequency of from about 1 Hz to about 20 kHz, at a
4 pulse width of about 5 microseconds to about 40 microseconds applied to bias the
5 tubular structure.

1 15. The method of claim 1, wherein said positioning includes positioning
2 the tubular structure and the magnetic field source within a vacuum chamber, such
3 that said exposing is performed under a vacuum.

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1 16. A method for coating an interior surface of a ferromagnetic tubular
2 structure, said method comprising:
3 positioning a ferromagnetic tubular structure and a magnetic field source in
4 the vicinity of one another;
5 operating the magnetic field source to induce a magnetic field of a given
6 magnitude within the tubular structure;
7 applying a bias at a given voltage to the tubular structure; and
8 exposing the interior surface to a gaseous precursor material under conditions
9 effective to convert a quantity of the gaseous precursor material to
10 ionized gaseous precursor material, the given magnitude and the given
11 voltage being effective to deposit the ionized gaseous precursor
12 material onto the interior surface and to convert the ionized gaseous
13 precursor material to a protective coating along a length of the interior
14 surface.

1 17. The method of claim 16, wherein said positioning includes providing a
2 tubular structure having a high aspect ratio.

1 18. The method of claim 16, wherein said positioning includes positioning
2 a magnetic field assembly, as the magnetic field source, within and along a length of
3 the tubular structure and generating the magnetic field therefrom during said inducing.

1 19. The method of claim 16, further comprising exposing the interior
2 surface of the tubular structure to inert gas, thereby cleaning the interior surface, prior
3 to exposing the interior surface to a gaseous precursor material and after inducing a
4 magnetic field.

1 20. The method of claim 19, wherein said gas is argon.

1 21. The method of claim 16, wherein said exposing includes selecting a
2 gaseous precursor material from the group of gaseous precursor materials consisting
3 of SiH_4 ; CH_4 ; C_2H_2 ; N_2 ; $\text{Cr}(\text{CO})_6$; and combinations thereof.

1 22. The method of claim 18, wherein said positioning includes positioning
2 a plurality of magnets within and along the length of the tubular structure, whereby,
3 during the inducing, a plurality of magnetic fields having the same direction are
4 generated.

1 23. The method of claim 18 further comprising, rotating at least one of the
2 tubular structure and the magnetic field source during said exposing.

1 24. The method of claim 23 further comprising, passing coolant during
2 exposing in the vicinity of said magnetic field assembly, thereby cooling said
3 magnetic field assembly.

1 25. The method of claim 24, wherein said passing includes passing water
2 in the vicinity of said magnetic field assembly.

1 26. The method of claim 18, wherein said applying a bias includes
2 applying a positive bias to said magnetic field assembly.

1 27. The method of claim 16, further comprising positioning the tubular
2 structure and the magnetic field source within a vacuum chamber, such that said
3 exposing is performed under a vacuum.

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1 28. The method of claim 16, wherein said exposing is performed under
2 conditions including a vacuum pressure of from about 0.5 to about 100 millitorr, and a
3 negative voltage having a pulse frequency of from about 1 Hz to about 20 kHz, at a
4 pulse width of about 5 microseconds to about 40 microseconds applied to bias the
5 tubular structure.

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1 29. A method for substantially uniformly coating an interior surface of a
2 ferromagnetic tubular structure having a high aspect ratio, said method comprising:
3 positioning a ferromagnetic tubular structure having a high aspect ratio
4 relative to a magnetic field source;
5 inducing a magnetic field having a given magnitude within the tubular
6 structure by operating the magnetic field source;
7 applying a bias at a given voltage to the tubular structure; and
8 exposing the interior surface to a gaseous precursor material under conditions
9 effective to convert a quantity of the gaseous precursor material to
10 ionized gaseous precursor material, the given magnitude and the given
11 voltage being effective to deposit the ionized gaseous precursor
12 material onto the interior surface and to convert the ionized gaseous
13 precursor material to a substantially uniform protective coating along a
14 length of the interior surface.

1 30. The method of claim 29, wherein said positioning includes positioning
2 a magnetic assembly, as the magnetic field source, within and along the length of the
3 tubular structure such that the magnetic field is generated from within the length of
4 the tubular structure.

1 31. The method of claim 30, further comprising exposing the interior
2 surface of the tubular structure to inert gas to clean the interior surface prior to
3 exposing the interior surface to a gaseous precursor material and after inducing a
4 magnetic field.

1 32. The method of claim 30, wherein said positioning includes positioning
2 the tubular structure and the magnetic field source within a vacuum chamber, such
3 that said exposing is performed under a vacuum.

1 33. The method of claim 32, further comprising rotating at least one of the
2 tubular structure and the magnetic field source during said exposing.

1 34. The method of claim 33, further comprising passing coolant during the
2 exposing in the vicinity of said magnetic field assembly, thereby cooling the magnetic
3 field assembly.

1 35. The method of claim 33, wherein said applying a bias includes
2 applying a positive bias to the magnetic field source.

1 36. The method of claim 29, wherein said exposing includes selecting a
2 gaseous precursor material from the group of gaseous precursor materials consisting
3 of SiH_4 ; CH_4 ; C_2H_2 ; N_2 ; $\text{Cr}(\text{CO})_6$; and combinations thereof.

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- 1 37. A tubular structure formed of a ferromagnetic material, said tubular
2 structure comprising an outside surface, an inside surface, and a gaseous deposition
3 product substantially uniformly coating said inside surface, wherein said tubular
4 structure has an aspect ratio of at least about 3.
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